Screening for Childhood Lead Poisoning: A Cost-Minimization Analysis

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ABSTRACT

Decision analysis was used to compare the costs of three screening strategies for childhood lead poisoning: (1) venipuncture; (2) capillary sample with venipuncture confirmation if the blood lead level is elevated; (3) stratification by risk, with venipuncture for high-risk children and capillary sample for low-risk children. Under baseline conditions, the cost of screening by the venipuncture, stratification, and capillary strategies is $22, $25, and $27, respectively. Venipuncture remains the least expensive strategy unless the cost of venipuncture is more than three times that of capillary sampling. The annual cost of a national lead screening program that uses a single venipuncture sample would be $352 million. Initial screening with a capillary sample would cost $432 million, 23% more than venipuncture. (*Am J Public Health.* 1994;84:110–112)

Introduction

Lead poisoning is one of the most common and preventable illnesses of childhood. It is estimated that one of every six United States children has an elevated blood lead level (≥0.72 μmol/L [15 μg/dL]), which is associated with adverse health effects.[1] The 1991 Centers for Disease Control (CDC) guidelines for lead screening differ significantly from earlier versions.[2] The CDC now recommends universal blood lead screening for all US children under age 6 years, except for children in communities that can demonstrate that they do not have a childhood lead poisoning problem. A blood lead level is now recommended as the primary screening test, rather than the erythrocyte protoporphyrin level, because erythrocyte protoporphyrin screening is not sufficiently sensitive to detect most children with blood lead levels above 1.21 μmol/L (25 μg/dL).[3–5]

The guidelines advise that a level of 0.72 μmol/L (15 μg/dL) or greater from a capillary sample should be confirmed by a venous sample because capillary samples may be falsely positive. Between 22% and 29% of capillary samples were found to be falsely elevated when the blood lead level of concern was 1.93 μmol/L (40 μg/dL),[6] so the false-positive rate is likely to be at least as high if the threshold is lower. However, obtaining specimens by venipuncture is more difficult than capillary sampling, and initial screening by venipuncture is not widely used.[7] The objective of this study was to compare the costs of universal blood lead screening by different strategies.

Methods

We used decision analysis[8,9] to compare the costs of the following three strategies: (1) initial screening with a venipuncture specimen; (2) initial screening with a capillary specimen, with venipuncture confirmation if the blood lead level was ≥0.72 μmol/L (15 μg/dL); and (3) stratification according to risk level as determined by questionnaire and then screening high-risk children with a venipuncture specimen and low-risk children with a capillary specimen, with venipuncture confirmation for blood lead levels of ≥0.72 μmol/L (15 μg/dL).

Baseline estimates of variables in the model were obtained from the medical literature. Costs were obtained from the 1990 rate book of The Children's Hospital, Boston, Mass.[10] This rate book lists the same cost ($3) for phlebotomy by both venipuncture and capillary sampling. However, in the baseline analysis we estimated that the cost of phlebotomy by venipuncture was twice as expensive as capillary sampling to more closely simulate the national experience. Costs rather than charges were used for this analysis, because costs more accurately reflect true resource use. SMLTREE software[11] was used to construct and evaluate the decision tree. Sensitivity analysis was used to explore the effect of changing variables over a range of clinically reasonable values (Table 1).

Results

Given baseline prevalences and costs, initial screening of all children with a venipuncture specimen cost $22 per child, and screening by the stratification and capillary strategies cost $25 and $27, respectively.

Sensitivity analysis (Table 2) demonstrated that the venipuncture strategy was the least expensive strategy over almost the entire range of variables indicated in

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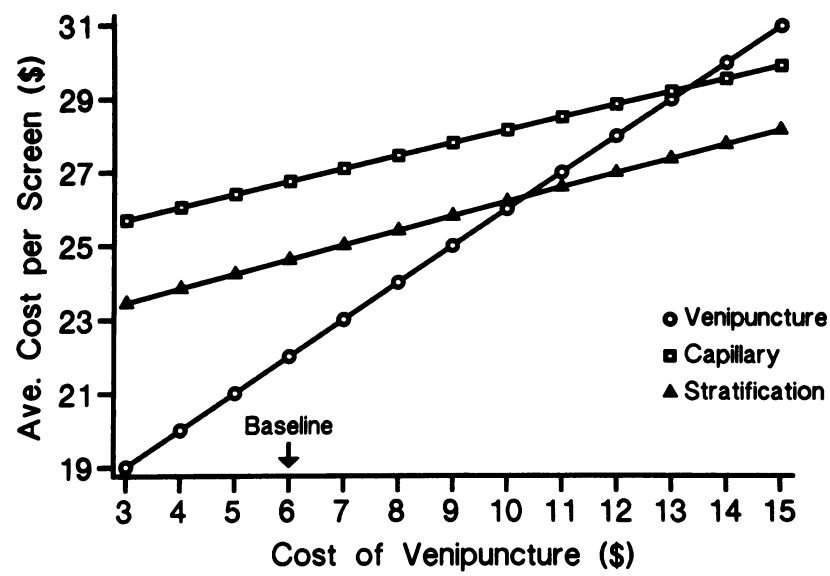
TABLE 1—Baseline Prevalence and Cost Estimates in the Model and Ranges Tested in Sensitivity Analysis

	Baseline (Range)	Reference
Prevalence of blood lead levels of ≥ 0.72 μmol/L (15 μg/dL) for all children	17% (1–50%)	1
Prevalence of blood lead levels of ≥ 0.72 μmol/L (15 μg/dL) for low-risk children	7.5% (0.5–10%)	1
Percentage of high-risk children	16% (1–50%)	1
False-positive rate	22% (5–50%)	6
Cost of phlebotomy for venipuncture specimen	$6 ($3–15)	10 and authors' estimate
Cost of phlebotomy for capillary specimen	$3 ($1–10)	10
Cost of blood lead analysis	$16 ($5–75)	10
Cost of erythrocyte protoporphyrin analysis	$0 ($0–15)	10

TABLE 2—Sensitivity Analysis of Selected Variables: Cost per Child According to Screening Strategy

	Value Tested	Cost of Screening Strategy, $		
		Venipuncture	Stratification	Capillary
Cost of blood lead analysis (baseline value = $16)	$5	11	11	12
	$35	41	48	52
	$75	81	97	107
Cost of phlebotomy for venipuncture specimen (baseline value = $6)	$3	19	23	26
	$9	25	26	28
	$15	31	28	30
Prevalence of blood lead levels of ≥ 0.72 μmol/L (15 μg/dL) (baseline value = 17%)	1%	22	24	24
	5%	22	24	25
	30%	22	25	29
Cost of phlebotomy for venipuncture specimen ($10) and prevalence of blood lead levels of ≥ 0.72 μmol/L (5%) (baseline values = $6 and 17%, respectively)		26	25	26
False-positive rate (baseline value = 22%)	5%	22	22	24
	35%	22	27	29
Cost of erythrocyte protoporphyrin analysis (baseline value = $0)	$5	27	31	34
	$10	32	37	40
	$15	37	43	47

Note. See Table 1 for baseline values for all variables.



Note. Venipuncture is the least expensive strategy unless the cost of venipuncture exceeds $10 per sample. The capillary strategy is more costly than the venipuncture strategy if the cost of venipuncture is less than $13 per sample. In the baseline analysis, the costs of venipuncture and capillary sampling were estimated at $6 and $3 per sample, respectively. Ave. = average.

FIGURE 1—The cost of lead screening plotted as a function of the cost of venipuncture.

Table 1. Because venipuncture is the final step in all the screening strategies, and because the cost of laboratory analysis is the same for capillary and venous samples, the venipuncture strategy is the least expensive strategy unless the cost of venipuncture phlebotomy is more than three times higher than the cost of capillary sampling (Figure 1).

As the prevalence of elevated blood lead levels decreased from 17% (baseline) to 5%, the cost of the venipuncture strategy was unchanged ($22). However, the cost of the stratification ($24) and capillary ($25) strategies decreased, reducing the added cost of these strategies compared with the venipuncture strategy. Under conditions of low prevalence (5%) and a high cost of venipuncture ($10), the stratification strategy ($25) became less expensive than either the venipuncture ($26) or capillary ($26) strategies.

If only 5% of the capillary samples are falsely elevated, the cost of screening by venipuncture would be the same as the cost of the stratification strategy ($22), but would remain less expensive than the capillary strategy ($24).

In our baseline analysis, we assumed that only blood lead analysis would be performed. However, erythrocyte protoporphyrin levels are often used as an adjunctive test for managing childhood lead poisoning. If erythrocyte protoporphyrin testing ($10) is included in the screening strategies, the venipuncture strategy ($32) would become even less expensive relative to the stratification ($37) and capillary ($40) strategies.

Discussion

This analysis demonstrates that a single venipuncture sample is the least

costly method of universal screening for childhood lead poisoning. The CDC recommends annual screening for children at low risk for lead poisoning and screening at 6-month intervals for high-risk children. Based on the US Public Health Service estimates,[1] 16 million blood lead screening tests on children under age 6 years will be required annually. According to our model, a lead screening program that uses a single venipuncture sample would cost $352 million per year. The annual costs of screening by the risk stratification and capillary strategies would be $400 million and $432 million, respectively, a 14% to 23% increase over the cost of screening with a single venipuncture sample.

Sensitivity analysis demonstrated that the venipuncture screening strategy is the least expensive approach over a wide range of prevalences, false-positive rates, and costs. For populations with a low prevalence of elevated blood lead levels, initial screening with capillary specimens may appear to be a more attractive strategy, at minimal additional average cost. However, because of the large numbers of screening samples required in areas of even moderate prevalence and the high rate of necessary rescreening because of false-positive results, the overall additional annual expenditure generated by this approach is considerable.

Issues of time, availability of skilled pediatric phlebotomists, convenience, and child/parent preference for the method of sampling were not considered in this analysis. Although initial screening by capillary sample may appear to be simpler than initial screening by venipuncture, that may not be true if a confirmatory sample by venipuncture is required.

This analysis indicates that methods for childhood lead screening differ substantially in cost. Better data are needed regarding the false-positive rate by capillary sampling now that the blood lead level requiring rescreening is 0.72 μmol/L (15 μg/dL). In addition, improved capillary sampling techniques that eliminate the need for venous confirmatory samples are needed. However, based on current information and existing techniques, a screening strategy that uses a single venipuncture sample can reduce the cost of screening for childhood lead poisoning. □

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